

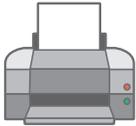
Piezoelectric ceramics are widely used in home appliances everyday. However, the problem of that the most of piezoelectric ceramics contains lead still remains. Consequently, the challenge for us has been to develop a lead-free piezoelectric ceramic material to prevent lead from leaching from discarded equipment into the environment. NGK SPARK PLUG has developed lead-free piezoelectric ceramics with characteristics that are comparable to ceramics contained lead.

Piezoelectric ceramics

Piezoelectric ceramics generate a voltage under an externally-applied force. Conversely, they elongate or contract when a voltage is applied. When an AC voltage is applied, they repeat elongation and contraction or vibrate and even generate ultrasound. In other words,

piezoelectric ceramics are capable of converting electrical energy to mechanical energy. By making full use of this capability, piezoelectric ceramics are used in a wide range of applications from home appliances to industrial equipment that ordinary people do not handle.

Familiar examples of applications of piezoelectric ceramics



Printer ink head

Ink chambers made of piezoelectric ceramics change shape to eject ink.



Camera lens autofocus motor

The camera focuses automatically. The lens is marked "USM."



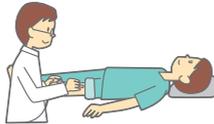
Speaker

Without sound emission holes, you can hear sounds when you put the cellphone's display screen to your ear.



Medical ultrasonography

Diagnostic sonography is used to check the sex and growth of fetuses and diagnose abdominal diseases.



Ultrasonic catheter

Uses ultrasound to view the inner walls of blood vessels despite the presence of blood.



Spectacles cleaner

Uses ultrasound to clean spectacles.



Knock sensor

Detects knocking.

Rear sensor

Alerts when the car approaches an obstacle.



Vibration-powered generator

Converts the power in your steps into electricity.

Contained lead in piezoelectric ceramics is the problem.

Lead zirconate titanate (PZT) is commonly used as a piezoelectric ceramics. As its name suggests, PZT contains lead. Since lead is poisonous, concern remains over how to dispose of products including PZT. If products including PZT are not properly treated, contained lead may leach from such products and contaminate soil and rivers and eventually affect human health. Regulations on the use of lead are therefore being tightened in Europe and other regions. Nonetheless, PZT-based piezoelectric

ceramics are still in use since they are not regulated under the RoHS directive in Europe at present. Because it is technically difficult to substitute electronic ceramics including lead such as PZT.

Although there are currently no restrictions on electronic ceramics contained lead, regulations on the use of lead are expected to be tightened. Consequently, it is important to develop lead-free piezoelectric ceramics that have characteristics comparable to PZT.

Development of lead-free piezoelectric materials

Sodium potassium niobate (KNN) is a promising substitute material for PZT. However, one significant challenge of developing KNN material has been acquiring stability of the material in addition to improvements to the characteristics because crystal grains of KNN are dice-like particles and it tends to have voids between the grains. To address this challenge, NGK SPARK PLUG has conducted research for several years and successfully developed a lead-free piezoelectric material by mixing a phase primarily composed of KNN and another phase (named "NTK phase"). Sintered ceramic of this material has very dense structure and characteristics close to PZT. We made our knock sensor using this newly-developed

material and tested it. The new material has proven to have performance comparable to PZT and that suggest that it should be possible to put into practical use.

We will continue our research and make efforts to commercialize lead-free piezoelectric ceramics.



Newly-developed lead-free piezoelectric material



Lead-free piezoelectric element and knock sensor



voice

Kazushige Obayashi
Engineering R&D Group

KNN lead-free piezoelectric material was discovered more than 50 years ago. Nearly 15 years have passed since we took on the challenge of developing the material. Researchers worldwide have increased their expectations and conducted research. However,

commercialization is still on the way. The length of time demonstrates how difficult the material is to and how attractive it is. Nonetheless, the result which commercialization of the material attains has been obtained in the last few years at last. This is a result of the efforts and enthusiasm of our research staff. I am genuinely grateful to the recent help received from many people, and we are now determined to launch the lead-free piezoelectric material on the global market.